The Behavior Analyst 1981, 4, 143-152 No. 2 (Fall)

Describing Response-Event Relations: Babel Revisited

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The terms used to describe the relations among the three components of contingencies of reinforcement and punishment include many with multiple meanings and imprecise denotation. In particular, usage of the term "contingency" and its variants and acceptance of unsubstantiated functional, rather than procedural, descriptions of response-event relations are especially troublesome in the behavior analysis literature. Clarity seems best served by restricting the term "contingency" to its generic usage and by utilizing procedural descriptions of response-event relations.

And the Lord said, "Behold, they are one people, and they have all one language; and this is only the beginning of what they will do; and nothing that they propose to do will now be impossible for them. Come, let us go down, and confuse their language, that they may not understand one another's speech." (Genesis 11:6-7)

Science is concerned with the generation, description, and categorization of relations. Contingencies of reinforcement, which Skinner (1969) defined as "the interrelations among S^D [a discriminative stimulus], R [a response], and S^{rein} [reinforcement]" (p. 23), are of particular interest to behavioral scientists. Beginning with Skinner (1938), attention has focused on the experimental analysis of such contingencies. Controversy persists, however, concerning the appropriate definition of stimuli (Gibson, 1960; Skinner, 1938), responses and their generic classes (Schick, 1971; Skinner, 1935), and reinforcement (Michael, 1975). There are, in addition, a number of ambiguities concerning the proper use of each of these terms (Catania, 1969, 1973).

The three components described in a reinforcement contingency are of theoretical interest because the variety of relations which can be arranged or which occur naturally among them determine how behavior is controlled (Skinner, 1938). Unfortunately, a consistent vocabulary for describing the relations among the components does not exist. For example, in major texts on learning phenomena, Hendry (1969, p. 104) and Halliday and Boakes (1972, p. 74) pointed to the lack of a common vocabulary for describing reinforcers delivered independently of responding. Such an absence led to a proliferation of idiosyncratic terms and descriptions. This paper reviews the various descriptions of the relations among discriminative stimuli, responses, and consequences, with an emphasis on the response-reinforcer relationship. We propose that major sources of difficulty arise from multiple and inconsistent usages of the word "contingency" and its variants, and acceptance of imprecise functional descriptions of response-event relations. These themes are developed subsequently and a case is made for severely restricting the use of the term "contingency," while removing functional descriptions unsubstantiated by supporting data from the parlance of behavior analysts.

RELATIONS BETWEEN STIMULI AND RESPONSES: CONTINGENCY, DEPENDENCY, AND CONTIGUITY

In a contingency of reinforcement (or punishment), two relations may exist between different stimuli, between dif-

Supported in part by a National Science Foundation grant to West Virginia University, K. A. Lattal, principal investigator. We are indebted to Anne Bryan, Wayne Fuqua, Jack Michael, Linda Parrott, and Julie Vargas for their comments on earlier drafts of this paper. Reprints may be obtained from K. A. Lattal, Department of Psychology, West Virginia University, Morgantown, West Virginia 26506.

ferent responses, and between stimuli and responses: (1) an event, such as delivery of food, may occur as a result of a second event, such as a response or the nonoccurrence of a response, or (2) the two may occur independently of one another. An example of the former relation between stimuli is a Pavlovian delayed conditioning paradigm in which the unconditional stimulus occurs only after presentation of the conditional stimulus. The random presentation of the two stimuli with respect to one another exemplifies the second relation (cf. Rescorla, 1967). The most widely studied examples of these relations, however, are those between responses, time, and events like food or electric shock in schedules of reinforcement or punishment, which specify whether a stimulus (e.g., food or electric shock) is to be delivered only if a particular response occurs or if it is to be delivered independently of the organism's behavior. In the latter relation, occurrence of the events depends only on the passage of time.

Catania (1969) distinguished between procedural, or operational, and functional, or process, definitions of reinforcement and punishment. In a procedural definition, emphasis is on the programming of the independent variable, while a functional definition emphasizes the effect of environmental alteration (manipulation of the independent variable) on behavior (the dependent variable). Like "reinforcement" and "punishment," the term "contingency" and its variants have been used both with reference to independent variables and to (sometimes speculative) relations between responding and some other event. When describing contingencies of reinforcement and punishment, the words "reinforcement" and "punishment" often are excluded and the abbreviated forms, "contingency" or "contingencies" are used.

One use of "contingency" is to describe the conditions of reinforcement or punishment. For example, "we describe the contingency by saying that a stimulus . . . is the occasion upon which a response is followed by reinforcement" (Skinner, 1953, p. 108) or contingency is "the effect of a response on the probability of a stimulus" (Catania, 1979, p. 82). Zeiler (1972) suggested when contingency thus "describes an independent variable . . . [it] . . . is synonymous with schedule, that is, it states the conditions under which reinforcement will occur" (p. 4). While stimulus conditions are often unstated in the description of single schedules, they are typically included when they vary (e.g., during a multiple schedule). "Contingency" may also emphasize a dependent variable by describing the relation between responses and subsequent events. For example, Nevin (1973) discussed "contingencies resulting from reinforcement schedules" (p. 211). Zeiler (1972) noted that "when so used, contingency is not synonymous with schedule but refers to the behavior that happens to occur prior to [another event]" (p. 5) regardless of whether the response produces the event. When the term is used in this manner, all events that follow and influence the probability of an observed response involve reinforcement or punishment contingencies, although the relation between these events and responses or other events is not described precisely.

"Contingency" and "contingent" are variants of one another; both derived from the Latin, and later French, word *contingent*. The adjective "contingent" has several definitions:

> 1. Touching each other, contact; tangential. . . . 2. Liable to happen or not; of uncertain occurrence or incidence. . . . 3. Happening. . . . 4. Happening or coming by chance; not fixed by necessity or fate; accidental, fortuitous. . . . 5. Not determined by necessity in regard to action or existence; free. . . . 6. Subject or at the mercy of accidents; liable to chance and change. . . . 7. Not of the nature of necessary truth; true only under existing conditions. . . . 8. Dependent for its occurrence or character *on* or *upon* some prior occurrence or condition (The Oxford English Dictionary, 1933, pp. 905-906)

The noun "contingency" is defined similarly. Reynolds (1968) distinguished contingent relations between other events and responses from dependent relations: "An event is said to be dependent on behavior if the event *must,* by the nature of the situation, occur following the behavior. An environmental event is said

to be *contingent* on behavior if the event does in fact follow the behavior but *need not* do so" (p. 34). Reynolds' distinctions are notable because they differentiate a programmed relation, i.e., a dependency, and an obtained relation, i.e., a contingency, between events and responses (cf. also Catania, 1968).

The relation of temporal contiguity to dependent or contingent events is not explicit in any of the preceding distinctions and examples. Reynolds describes events as *following* behavior, but "follow" is not defined precisely. Reynolds' dependent and contingent relations historically have implied temporal contiguity between an environmental event and a specified response. That is, the response is immediately followed by the event (cf. Zeiler, 1968, p. 411). Temporal contiguity is not, however, a necessary part of the definition of either relation. In the case of a dependent relation, an environmental event can occur only if a particular response is emitted but the required response may be temporally separated from the event. Delay of reinforcement experiments exemplify this type of dependent relation (e.g., Sizemore & Lattal, 1977). Another example of a dependent relation without necessary temporal contiguity is the concept of correlation suggested by Baum (1973). He cited an unpublished experiment in which a pigeon's rate of reinforcement was positively correlated with its rate of key-pecking. That is, higher rates of reinforcement were dependent upon higher rates of key-pecking but, on a molecular level, reinforcement was not necessarily contiguous with individual key pecks.

THE NOMENCLATURE OF RESPONSE-EVENT RELATIONS

The most common empirically investigated relation is that between responding and some other event, e.g., delivery of a putative reinforcer or punisher. (These latter terms are used herein only to describe stimuli such as food or electric shock and not to describe the behavioral effects of the stimuli. Similarly, except as noted, the term "reinforcement" will be used only in its procedural sense to describe delivery of a reinforcer.) As a result, many descriptions of the response-event relation exist. The remainder of the paper will focus on analyzing descriptions of this relation, although the nomenclature that follows applies equally to relations among any of the components of Skinner's three-term contingency. These descriptions are dichotomized into procedural and functional ones (cf. Catania, 1969, 1979).

Procedural Descriptions

Perhaps the most widely used expression to describe reinforcers which are presented only if a response occurs is "contingent reinforcement." The relation often is described as a "response-reinforcer contingency." The origin of this expression is unknown, but Ferster and Skinner's (1957) reliance on it seems to have firmly established its usage in subsequent behavior analytic work. One of the several definitions of "contingent" is "dependent," and so the use of the term "contingent," modified by "response," is formally correct. However, the multiple definitions of "contingent" allow quite different interpretations of the relation between responding and reinforcement than that of the former producing the latter. For example, under Reynolds' (1968) definition of "contingent," "response-contingent reinforcement" describes a sequence in which an event follows a response but, procedurally, the response is not required. Schoenfeld and Farmer (1970) noted that the use of contingency to indicate that an event follows a response more or less immediately is too imprecise to be useful: ". . . [in] this loose sense noncontingent reinforcement is never possible. If the experimentally observed [response] ever occurs, then a subsequent reinforcement at any later time 'follows' [the response]" (p. 221).

Confusion also may occur between "contingency" as a description of a specific relation between responding and other events and the generic usage of "contingency" to describe more generally the conditions of reinforcement or punishment. Thus, "non response-

contingent reinforcement" can be said to be one part of a contingency (of reinforcement) as can "response-contingent reinforcement." Catania (1979) argued that "contingent stimulus" is justifiable even in the case of stimuli delivered without regard to behavior, "because this operation is the limiting case of contingencies; . . . it is useful to be able to refer to this case as a special kind of contingency even though it has no effect on stimulus probability" (p. 222). That such an operation is a contingency seems beyond quesiton; to use "contingent" or "contingency," however, to describe two very different relations between responding and other events is, at the least, awkward and counter-intuitive.

Another problem with "contingent reinforcement" concerns its antonym. Possibilities include "non-contingent" (Appel & Hiss, 1962), "nonresponse contingent" (Davis, Hubbard, & Reberg, 1973), "response non-contingent" and "non response-contingent" reinforcement. The first is inaccurate when the reinforcer is at least contingent upon the passage of time (cf. Herrnstein, 1966; Zeiler, 1972). The second implies that the reinforcer follows a "nonresponse" as in a schedule requiring the absence of a particular response for some period for reinforcement. The last two may be correct if "contingent" is defined as dependent. If, however, contingencies "properly refer to events which are *not* specified as necessities but which may occur" (Zeiler, 1972, p. 4), then the term "non-contingent" invokes a double negative and could be interpreted to mean necessary. Both the double negative and the notion that non response-contingent reinforcement is one type of reinforcement contingency argue against the continued use of these terms. Clarity dictates that the term "contingency" be restricted to Skinner's (1938, 1969) generic usage and that different terms be selected to describe the relation between specific events within a contingency of reinforcement or punishment.

Skinner (1938, p. 163; Ferster & Skinner, 1957, p. 684) described the operation of delivering reinforcers independently of responding as "uncorrelated reinforcement" to distinguish it from operations in which reinforcement requires response occurrence (positive correlation) or omission (negative correlation) of a particular response (Skinner, 1938, p. 160). However, Kelleher and Gollub (1962) described the terminal link of Autor's (1960) concurrent chain variable-interval differential-reinforcement-of-other-behavior schedule as an example of an uncorrelated schedule. Under this schedule, the omission of a particular response was required for reinforcement; Skinner (1938) labeled this relation a negative correlation. In addition to this historical inconsistency in usage, the term "correlation" is somewhat misleading for, in a conventional *statistical* sense, correlation does not imply a cause-effect relationship between two variables, but rather only that the two are mathematically related. Two variables, such as response rate and frequency of reinforcement delivered independently of responding, may be positively correlated in a statistical sense (e.g., Lachter, 1971), yet according to Skinner's (1938) terminology the response-reinforcer relation at a molecular level would be termed uncorrelated. To add further to the confusion, "correlation" has been used by Baum (1973) to describe molar relations between reinforcement frequency and responding and not molecular relations between individual responses and reinforcers.

Halliday and Boakes (1972) suggested the terms "dependent" and "free" to describe the two types of response-reinforcer relations. Aside from the fact that the two terms lack a logical symmetry, "free" food has been used predominately to describe the availability of *ad libitum* food in the operant chamber during conditioning of responses (Neuringer, 1969).

Another possibility is to describe, in the case of the response-reinforcer relation, the response as being relevant or irrelevant to reinforcement (Kellogg, 1949). These terms lack sufficient precision to be recommended since "relevant" connotes a sufficiency relation but not a necessary relation between two events. "Relevant"

also may be taken to imply a biological tie between response and consequence, e.g., key-pecking may be "biologically relevant" to food procurement by pigeons, but "irrelevant" to shock-avoidance (cf. Seligman & Hager, 1972).

The clearest procedural description of reinforcement contingencies which involve response requirements is to describe the relations as response-dependent. If response requirements are not imposed, the relation is described as response-independent (cf. Zeiler, 1968). This usage has been increasingly adopted in the behavior analysis literature, although there still are numerous exceptions. While we agree with Catania (1979) that other terms might be equally acceptable, several desirable features of these terms can be noted: (1) the distinction between the generic "contingency of reinforcement" and the description of the interrelations among the three terms is clear; (2) procedurally, "dependent" and "independent," are in logical juxtaposition with one another; and (3) the terms themselves are unambiguous in definition.

These terms leave other problems unresolved, however. "Response-dependent" and "response-independent" often are used to modify the term "reinforcement." This can be a source of confusion if reinforcement is used in a functional sense, referring to an increase in response probability following presentation of a stimulus. For example, the usual effect of removing the response-reinforcer dependency is to reduce the frequency of the measured response. Thus, "response-independent reinforcement" represents a logical contradiction between the functional definition of reinforcement and this obtained effect on the measured response. If the term "reinforcement" refers only to the delivery of food or other events, ambiguity is avoided. Another problem lies in distinguishing a dependent relation in which the response is immediately followed by a reinforcer from a dependent relation in which the reinforcer may not immediately follow the response (e.g., Sizemore & Lattal, 1977). Use of appropriate modifiers, such as "delayed," may prevent this ambiguity. A third problem exists if an event is dependent on the non-occurrence of a specific response so that each response delays presentation of the event. This relation involves a clear dependency between responding and the event, but the relation is negative. Using a valence, i.e., positive or negative, to modify "dependency" distinguishes a response-produced event from this type of response-delayed event.

Functional Descriptions

The preceding procedural definitions emphasize the programmed relation between responding and other events. Functional descriptions indicate or imply the actual (temporal) relation between a response and an environmental event, although this relation is more often assumed than assessed. In one such functional description, Azrin (1956) used the terms "immediate" and "non-immediate" to describe the relation between electric shock delivery and responses. The former term described the case where a response produced the electric shock and the description is accurate, i.e., the shock immediately followed the response (note that with the term "immediate," description of a delayed dependency is not possible). The latter term described the case when shock occurred without regard to behavior. It is imprecise since whether the shocks occurred immediately or some time after a response was not measured. A similar criticism applies to other, more contemporary, process descriptions in which reinforcement (or punishment) is dichotomized as "contiguous" or "non-contiguous" or as "response-contingent" or "response-non-contingent" because the relation between responses and the reinforcer (or punisher) rarely is determined. Functional descriptions of this sort assume that the two opposed terms (e.g., "contiguous" and "non-contiguous") describe different functional relations between responding and events, but in the absence of actual observations of such relations, these descriptions are only hypothetical analyses that may "confuse a theoretical account of the [behavioral] effects of

[reinforcement] schedules with a simple description of the prescription of reinforcer delivery" (Zeiler, 1977, p. 203).

The terms "adventitious" or "accidental" reinforcement or punishment often are used in accounting for "superstitious" behavior. As with the terms described in the preceding paragraph, adventitious or accidental reinforcement implies a particular functional relation between responding and events delivered independently of the observed response. One difficulty with these expressions is that common antonyms that describe response-produced reinforcement or punishment include "real," "deliberate," "intentional," or "purposeful." The more serious problem is with the precision of expressions like "adventitious reinforcement results in superstitious behavior." The same learning processes operate when responses produce environmental events and when such events occur without regard to behavior. The distinguishing feature of responding under these two types of response-reinforcer (or punisher) relations is not the degree of "realness" of the behavioral changes, but rather whether the relations are programmed or not and whether the response topography is stable across time (cf. Herrnstein, 1966).

Labeling responding as "superstitious" adds little to its description and seems inevitably to lead confusion over its cause. Skinner (1948) said of his results when pigeons were given response-independent food under a fixed-time schedule: "The experiment might be said to demonstrate a sort of superstition. The bird behaves as if there were a causal relation between its behavior and the presentation of food, although such a relation is lacking" (p. 171). What Skinner presented as metaphor was interpreted more literally by Kellogg (1949):

> By adding the concept of causality [to responses maintained by response-independent reinforcement] one makes of them superstitions in the literal sense, since the organism is now conceived of as ascribing unreal or unnatural causes to a straight forward series of events. Rather than being ordinary instances of the association of movements in series, they are looked upon as cognitive or purposive acts (p. 171).

While it is unlikely that Skinner or other behavior analysts would accept such a view of superstition, it is not difficult, as Kellogg illustrated, for metaphor to be seen as reality.

"Adventitious reinforcement" and "superstitious behavior," respectively, have long been a panacea to account for and describe responding of unknown origins and/or controlling variables. The use of such descriptions can be a substitute for careful experimental analysis. After such analyses, some investigators (e.g., Rescorla & Skucy, 1969; Staddon & Simmelhag, 1971) have questioned the empirical soundness of these concepts. While many behavior analysts may not yet be ready to bury the label "superstitious," serious consideration should be given to doing so. In raising this possibility, we empathize with Bolles (1967) who, after a thoughtful review of the drive concept, eulogized its passing in a compelling, if flowery, passage which is equally appropriate in laying superstitious behavior to rest:

> The concept is like an old man that has had a long, active, and, yes, even useful life. It has produced a notable amount of conceptual and empirical work; it has, perhaps indirectly, made a great contribution to our understanding of behavior. But the fruitful days are nearly gone. The time has come when younger, more vigorous, more capable concepts must take over. So, as sentimental as we may feel about our old friend, we should not despair at his passing (pp. 329-330).

NOMENCLATURE OF RESPONSE-EVENT RELATIONS IN REINFORCEMENT SCHEDULES

With a few exceptions, descriptions of particular reinforcement (or punishment) schedules have been procedural and unambiguous since Skinner's earliest writings. However, as shown below, terminology is confused and functional descriptions are commonplace with respect to schedules that involve the response-independent occurrence of events, and with respect to what Zeiler (1977) generically has termed "differentiation" schedules.

Schedules Delivering Response-Independent Events

A variety of descriptions of schedules

involving response-independent food presentations have been suggested. These include "free interval" (Halliday & Boakes, 1972), "accidental" schedules (Weisberg & Kennedy, 1969), "noncontingent" schedules (Schoenfeld & Cole, 1975) and "time" schedules (Zeiler, 1968). The latter procedural description clearly distinguishes such schedules from interval schedules employing response-dependent reinforcement. It also avoids the connotation of unlimited access to a stimulus that is implied by "free" (see previous section) and does not connote a capricious procedure such as is suggested by "accidental." Consequently, it seems a useful, if somewhat arbitrary, term for describing such operations.

Several investigators (Lattal & Bryan, 1976; Rachlin & Baum, 1972; Zeiler, 1976) have used schedules in which response-dependent and response-independent reinforcement occur in the presence of a single operandum. Such combinations have been described as concurrent (Lattal & Bryan, 1976; Rachlin & Baum, 1972) and as conjoint (Zeiler, 1976). Concurrent schedules "involve reinforcement of two or more responses according to two or more schedules at the same time" (Reynolds, 1968, p. 89). Thus, it can be argued that two general classes of responses exist which might be affected by response-independent reinforcement: operant responses, producing the response-dependent reinforcement; and other response classes, not programmed to deliver reinforcers. The difficulty with this description is the same as that for other process-based descriptions: other responses are seldom monitored and the relation between such responses and response-independent reinforcement is not known. Conjoint schedules refer to reinforcement of the same response according to two independent schedules. However, if response-dependent and response-independent reinforcers are delivered together, it remains an empirical question as to which and how many response classes are being affected by each type of reinforcer. Perhaps the best description of such schedule combinations is procedural (e.g., "subjects were exposed to conditions in which fixed-ratio and fixed-time schedules of food delivery were simultaneously in effect") which, although cumbersome, is accurate and free of interpretive errors.

Differentiation Schedules

"In differentiation schedules reinforcers are presented when a response or a group of responses displays a specified property" (Zeiler, 1977, p. 203). The most commonly studied differentiation schedules are distinguishable as those which: (1) deliver the reinforcer only if the time between two successive responses (interresponse time, IRT) exceeds a specified value; (2) deliver the reinforcer only if the time between two successive responses is less than a specified value; or (3) deliver the reinforcer only if a certain response fails to occur during a specified period. Ferster and Skinner (1957) labeled the first two of these relations as the "differential-reinforcement-of low rates" (DRL) and the "differential-reinforcement-of-high-rates" (DRH), and Reynolds (1961) labeled the third "differential reinforcement of other behavior [than the measured response]" (p. 50). These designations continue to be used, especially in the applied literature (Poling & Ryan, 1981; Zeiler, 1977). However, the designations DRL, DRH, and DRO are based on prediction of the patterns of behavior likely, but not certain, to occur under each condition. As noted in the earlier discussion of process definitions, they inevitably confuse theoretical accounts of the schedule with the conditions for reinforcer delivery. For example, in the case of DRL schedules, the possible causes of low rates include the differential reinforcement of low rates in a molar sense (cf. Baum, 1973), the reinforcement of long IRTs, or the reinforcement of mediating response chains.

Because procedural descriptions avoid this difficulty, it seems preferable to substitute the procedural description IRT>t for DRL and IRT<t for DRH (cf. Zeiler, 1977). Several alternatives to DRO have been proposed including "omission training" and "differential-reinforcement-of-not-responding." The former

term traditionally has been used to refer to a respondent conditioning procedure where conditional responses prevent or delay delivery of the unconditional stimulus (Sheffield, 1965). The latter term has no such history, and seems the better choice. Schoenfeld and Farmer (1970) and Zeiler (1977) suggested the terminology $\bar{R}>t$ to describe this relation. Pennypacker (Note 1) noted a dimensionality problem with this expression in that responding or not responding is placed in a relational position to time. By specifying a duration of $\bar{R}$ ($d\bar{R}$), both sides of the term are expressed in temporal terms. Thus, replacing DRO with the expression $d\bar{R}>t$ allows the three generic forms of differentiation schedules to be described similarly (as IRT>t, IRT<t, and $d\bar{R}>t$), a desirable end in itself.

SUMMARY AND CONCLUSION

Contingencies of reinforcement and punishment are fundamental to a science of behavior. However, the definition and description of an important feature of such contingencies—the relations among the components—has resulted in confusion among those constructing the tower of behavior analysis. This situation was predicted by Another before him, but Krantz (1971) described it as follows: "innovating new terms without coordinating links leads to lack of understanding, insularity, and isolation" (p. 65). Such innovations have resulted in multiple usages and definitions of the same term, leading "to confusion and controversy often without awareness of the sources of disagreement" (Krantz, 1971, p. 65).

Much of this confusion derives from multiple usage of terms like "contingency" as both a generic term describing the interrelations among stimuli, responses, and reinforcers or punishers, and a description of a specific relation between responses and other events. Procedurally, these response-event relations are most clearly described as "response-dependent" or "response-independent." Behavior analysts have argued persuasively both for precision in describing and executing relations between responding and other events and for a functional analysis of behavior. One dimension of a functional analysis is the inclusion of functional, as well as procedural, definitions of terms (cf. Michael, 1975). In the case of describing response-event relations, these two objectives are in conflict because of the impreciseness of present attempts at functional descriptions. In particular, describing responding as "superstitious" is replete with conceptual and empirical difficulties. Functional descriptions of interrelations among stimuli and responses presently cannot be defended because the actual temporal relation between response and event seldom is measured (in the case of response-independent reinforcers), measures of changes in implied response classes are seldom made (in the case of $d\bar{R}>t$ schedules), and it is difficult to assess the type of operation (response-dependent or response-independent) responsible for a particular sample of responding. To make these descriptions truly functional would require an experimental analysis of all responses preceding reinforcement (cf. Staddon & Simmelhag, 1971) instead of the more typical analyses which focus on only one or two carefully defined operants (e.g., electronically recorded key pecks or bar presses). Several modifications in the vocabulary of response-event relations are suggested at the expense of brevity, established usage, and/or eloquence. However, in scientific endeavors it is often necessary to choose between such factors and precision. A decision in favor of the latter seems a small price to pay for eliminating the proliferation of terms and imprecise descriptions herein reviewed.

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